Attorney's Docket No. 015290-546

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of)
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David J. Cooperberg et al.) Group Art Unit: 1763
)
Application No.: 10/024,208) Examiner: Luz L. Alejandro Mulero
)
Filed: December 21, 2001) Appeal No.: Unassigned
)
For: TUNABLE MULTI-ZONE GAS)
INJECTION SYSTEM)
)

APPEAL BRIEF

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Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This appeal is from the decision of the Primary Examiner dated February 18, 2005, finally rejecting claims 1-11, 13-15 and 39-61, which are reproduced as the Claims Appendix of this brief.

☐ A check covering the ☐ $250.00 (2402) ☐ $500.00 (1402) Government fee is filed herewith.

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The Commissioner is hereby authorized to charge any appropriate fees under 37 C.F.R. §§1.16, 1.17, and 1.21 that may be required by this paper, and to credit any overpayment, to Deposit Account No. 02-4800.

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I. Real Party in Interest

The present application is assigned to Lam Research Corporation.

II. Related Appeals and Interferences

The Appellants' legal representative, or assignee, does not know of any other appeal or Interference, which will affect, or be directly affected by, or have bearing on, the Board's decision in the pending appeal.

III. Status of Claims

Claims 1-11, 13-15 and 39-61 are pending in this application, and are being appealed.

IV. Status of Amendments

No Amendments were filed subsequent to the final Final Official Action dated February 18, 2005.

V. Summary of Claimed Subject Matter

Each of the appealed Claims 1-11, 13-15 and 39-61 is directed to a plasma processing apparatus. Claims 1, 7, 9, 10, 41 and 42 are independent claims.

The plasma processing apparatus recited in Claim 1 comprises, *inter alia*, a plasma processing chamber; a dielectric member having an interior surface facing a substrate support and forming a wall of the processing chamber; and a gas injector extending through the dielectric member. The gas injector comprises a body including an axial end surface exposed within the processing chamber, a side surface extending axially from the axial end surface, and a plurality of gas outlets

including at least one on-axis outlet in the axial end surface and a plurality of spaced-apart off-axis outlets in the side surface. A common gas supply is in fluid communication with a first gas line and a second gas line. The first gas line is in fluid communication with the on-axis outlet, but not with the off-axis outlets. The second gas line is in fluid communication with the off-axis outlets, but not with the on-axis outlet. Flow controllers are operable to supply process gas from the common gas supply at flow rates that are independently varied between the on-axis outlet and the off-axis outlets into the processing chamber. An RF energy source inductively couples RF energy through the dielectric member and into the chamber to energize the process gas into a plasma state to process the substrate.

Portions of exemplary embodiments of the claimed plasma processing system are shown in Figures 2a-2c. As shown, the plasma processing system includes a dielectric member 20 having an interior surface (the bottom surface), and a gas injector 22 extending through the dielectric member 20. The gas injector 22 comprises a body including an axial end surface (the bottom surface) and a side surface, which extends (upwardly) from the axial end surface. An on-axis outlet 24 is provided in the axial end surface, and plurality of spaced-apart off-axis outlets 26 are provided in the side surface. A common gas supply (including a main gas supply 32) is in fluid communication with both a first gas line (the upper gas line along which the flow-restriction device 36b is arranged) and a second gas line (the lower gas line along which the flow-restriction device 36a is arranged). As recited in Claim 1 (and also in Claims 7, 9, 10, 41 and 42), the term "common gas supply" means that the gas supply is adapted to supply the same gas to each of the first and second gas lines (or first and second gas passages, as recited in Claim 42). The same process

gas that is supplied by the common gas supply to the first and second gas lines can be a single gas or a gas mixture. See page 12, lines 6-8, of the specification. The first gas line is in fluid communication with the on-axis outlet 24, but not with the off-axis outlets 26. The second gas line is in fluid communication with the off-axis outlets 26, but not with the on-axis outlet 24. See, for example, the description at page 12, lines 1-18, of the specification.

Exemplary advantages that can be provided by embodiments of the plasma processing system recited in Claim 1, for example, are described at page 9, lines 8-19, of the specification. As described, process performance can be measured by uniformity of etch rate, feature width and profile, fidelity of pattern transfer, and uniformity of pattern transfer. Optimal gas injection and optimal process performance can be achieved by being able to adjust the ratio of flow through the injector outlets. The flow controllers are operable to allow process gas to be supplied from the common gas supply to the on-axis and off-axis outlets at independently controlled flow rates, e.g., the ratio of flow through the on-axis and off-axis outlets may be varied by independent operation of the flow controllers. This balance between on-axis and off-axis injection determines the convective flow field downstream from the nozzle tip. The convective flow field can be used to modify the total flow in the chamber. As a result, the spatial density dependence of reactive species can be modulated in the plasma processing system. Thus, the plasma processing system provides tunable process gas injection and allows for optimized performance with a single set of hardware. For example, for different etch applications (and/or for different recipe steps within a given etch application) for which different ratios of on-axis to off-axis flow are desired for optimum uniformity,

the combination of the plasma processing system allows for variation of this ratio without tool modification.

The plasma processing system recited in Claim 7 comprises, *inter alia*, a gas injector extending through a dielectric member such that a distal end of the gas injector is exposed within the processing chamber. The gas injector includes a planar axial end face having an on-axis outlet therein and a conical side surface having off-axis outlets therein. The on-axis outlet receives process gas from a central passage in the injector and the off-axis outlets receive process gas from an annular passage surrounding the central passage. The gas injector supplies process gas at flow rates that are independently varied between at least some of the outlets including the on-axis outlet into the processing chamber. A common gas supply is in fluid communication with a first gas line and a second gas line, where the first gas line is in fluid communication with the on-axis outlet, but not with the off-axis outlets, and the second gas line is in fluid communication with the off-axis outlets, but not with the on-axis outlet.

The plasma processing system recited in Claim 9 comprises, *inter alia*, a gas injector extending through the dielectric member such that a distal end of the gas injector is exposed within the processing chamber. The gas injector includes a planar axial end face having an on-axis outlet therein and a conical side surface having off-axis outlets therein. The on-axis outlet receives process gas from a central passage in the injector and the off-axis outlets receive process gas from an annular passage surrounding the central passage. The gas injector supplies process gas at flow rates that are independently varied between at least some of the outlets including the on-axis outlet into the processing chamber. A common gas

supply is in fluid communication with a first gas line and a second gas line, with the first gas line being in fluid communication with the on-axis outlet, but not with the off-axis outlets, and the second gas line being in fluid communication with the off-axis outlets, but not with the on-axis outlet.

The plasma processing system recited in Claim 10 comprises, *inter alia*, a gas injector removably mounted in an opening in a dielectric member and extending through a dielectric member such that a single distal end of the gas injector is exposed within a processing chamber. A vacuum seal is provided between the gas injector and the dielectric window. See page 14, lines 14-23, of the specification. The gas injector includes a plurality of gas outlets in the single distal end, which are each located below the interior surface of the dielectric member. For example, in the embodiments shown in FIGS. 2a and 2b, the gas outlets 24, 26 are disposed below the inner surface of the dielectric member 20. The gas outlets supply process gas at flow rates that are independently varied between at least some of the outlets into the processing chamber. A common gas supply is in fluid communication with a first gas line and a second gas line, with the first gas line being in fluid communication with the on-axis outlet, but not with the off-axis outlets, and the second gas line being in fluid communication with the off-axis outlets, but not with the on-axis outlet.

The plasma processing system recited in Claim 41 comprises, *inter alia*, a gas injector body extending through a dielectric member such that a distal end of the gas injector body is exposed within a processing chamber. The gas injector body includes a plurality of gas outlets disposed within the processing chamber below the interior surface of the dielectric member. A common gas supply is in fluid communication with a first gas line and a second gas line, with the first gas line being

in fluid communication with at least one first outlet, but not with second outlets, and the second gas line being in fluid communication with the second outlets, but not with the first outlet. Flow controllers provide independently adjustable flow rates of process gas between at least some of the outlets into the processing chamber.

Lastly, the plasma processing apparatus recited in Claim 42 comprises, *inter alia*, a gas injector comprising an injector body including at least first and second gas inlets, at least first and second gas passages, an axial end surface, a side surface extending from the axial end surface toward the interior surface of the dielectric member, and at least a first gas outlet in the axial end surface and a plurality of second gas outlets in the side surface at locations between the axial end surface and the interior surface of the dielectric member. The first gas passage is in fluid communication with the first inlet and first outlet, and the second gas passage is in fluid communication with the second inlet and second outlet, wherein the first and second gas passages are not in fluid communication with each other. A common gas supply is in fluid communication with the first gas passage and the second gas passage. Flow controllers provide independently adjustable flow rates of gas through the first and second outlets.

VI. Grounds of Rejection to be Reviewed on Appeal

1) Claims 1-7, 9, 11, 13, 14, 39, 41-50 and 56-61 stand rejected under 35 U.S.C. § 103(a) as allegedly being obvious over WO 99/57747 to Chang ("Chang") in view of U.S. Patent No. 6,450,117 to Murugesh et al. ("Murugesh") and U.S. Patent

No. 5,958,140 to Arami et al. ("Arami"), or U.S. Patent No. 5,532,190 to Goodyear et al. ("Goodyear"), or U.S. Patent 6,090,210 to Ballance et al. ("Ballance").[1]

2) Claims 8, 10 and 40 stand rejected under 35 U.S.C. § 103(a) as allegedly being obvious over Chang in view of Murugesh and Arami, or Goodyear, or Balance, and further in view of WO 00/41212 to Ni et al. ("Ni").

3) Claim 15 stands rejected under 35 U.S.C. § 103(a) as allegedly being obvious over Chang in view of Murugesh and Arami, or Goodyear, or Ballance, and further in view of U.S. Patent No. 6,287,643 to Powell et al. ("Powell").

4) Claims 51-55 stand rejected under 35 U.S.C. § 103(a) as allegedly being obvious over Chang in view of Murugesh and Arami, or Goodyear, or Ballance, and further in view of U.S. Patent No. 4,270,999 to Hassan et al. ("Hassan").

VII. Argument

A. Claimed Subject Matter

Each of the independent Claims 1, 7, 9, 10 and 41 recites the features of "a common gas supply in fluid communication with a first gas line and a second gas line," and Claim 42 recites the features of "a common gas line in fluid communication with the first gas passage and the second gas passage." As discussed above, the claimed "common gas supply" is adapted to supply the same gas, at the same time, to the first and second gas lines, or the first and second gas passages. The applied

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[1] Claims 46 and 59 depend from independent Claim 10, which is not included in the group of claims rejected under this ground of rejection. Accordingly, Claims 46 and 59 will be addressed with respect to the second ground of rejection discussed below.

combinations of references fail to provide the required suggestion or motivation to modify Chang's apparatus to result in the plasma processing system recited in any one of Claims 1, 7, 9, 10, 41 and 42.

Claim 1 recites a plasma processing system, which comprises, *inter alia*, "a plasma processing chamber; ... a dielectric member having an interior surface facing the substrate support, wherein the dielectric member forms a wall of the processing chamber; a gas injector extending through the dielectric member, the gas injector comprising a body including an axial end surface exposed within the processing chamber, a side surface extending axially from the axial end surface, and a plurality of gas outlets including at least one on-axis outlet in the axial end surface and a plurality of spaced-apart off-axis outlets in the side surface; a common gas supply in fluid communication with a first gas line and a second gas line, the first gas line being in fluid communication with the on-axis outlet but not with the off-axis outlets and the second gas line being in fluid communication with the off-axis outlets but not with the on-axis outlet ...." (Emphasis added). The applied combination of references fails to suggest the subject matter recited in Claim 1.

B. Legal Standards for Obviousness

In order to establish a case of *prima facie* obviousness with respect to claimed subject matter, the Patent Office must establish (1) "some suggestion or motivation in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to ... combine the reference teachings"; (2) "a reasonable expectation of success"; and that (3) "the prior art ... references when combined ... must teach or suggest all the claim limitations." "The teaching or suggestion to make

the claimed combination and the reasonable expectation of success must both be found in the prior art, not in applicant's disclosure" (citation omitted). See MPEP § 2143 at page 2100-129, and MPEP § 2143.03 at page 2100-133.

As explained at MPEP § 2143.01, page 2100-131:

> [t]he mere fact that references can be combined or modified does not render the resultant combination obvious unless the prior art also suggests the desirability of the combination. *In re Mills*, 916 F.2d 680, 16 USPQ2d 1430 (Fed. Cir. 1990).

As stated by the Court of Appeals for the Federal Circuit in *In re Kotzab*, 55 USPQ2d 1313, 1316 (Fed. Cir. 2000):

> Most if not all inventions arise from a combination of old elements. *See In re Rouffet* , 149 F.3d 1350, 1357, 47 USPQ2d 1453, 1457 (Fed. Cir. 1998). Thus, every element of a claimed invention may often be found in the prior art. *See Id.* However, identification in the prior art of each individual part claimed is insufficient to defeat patentability of the whole claimed invention. *See Id.* Rather, to establish obviousness based on a combination of the elements disclosed in the prior art, there must be some motivation, suggestion or teaching of the desirability of making the specific combination that was made by the applicant. (Citations omitted; emphasis added).

Furthermore, "[a] prior art reference must be considered in its entirety, i.e., as a whole, including portions that would have led away from the claimed invention" (citation omitted). See MPEP 2141.02 at page 2100-127.

According to MPEP § 2145(X)((D)(2) at page 2100-162:

> It is improper to combine references where the references teach away from their combination. *In re Grasselli*, 713 F.2d 731, 743, 218 USPQ 769, 779 (Fed. Cir. 1983).

See also, *Winner Intl. Royalty Corp. v. Ching-Rong Wang*, 202 F.3d 1340, 53 USPQ2d 1580 (Fed. Cir. 2000).

If a proposed modification of the prior art results in the art becoming inoperable, or the modification destroys the art's intended function, then there would have been no motivation to make the proposed modification. As stated at MPEP § 2143.01, page 2100-131:

> If [the] proposed modification would render the prior art invention being modified unsatisfactory for its intended purpose, then there is no suggestion or motivation to make the proposed modification. *In re Gordon*, 733 F.2d 900, 221 USPQ 1125 (Fed. Cir. 1984).

See also, *In re Sponnoble*, 160 USPQ 237, 244 (CCPA 1969), in which the court held that a combination of references that would produce a seemingly inoperative device teaches away from the asserted combination. A combination of references that would destroy the device of the base reference for its intended purpose would not have rendered obvious the claimed subject matter. *See Ex Parte Westphalen*, 159 USPQ 507, 508 (Bd. App. 1967); *Ex Parte Hartmann*, 186 USPQ 366, 367 (Bd. App. 1974). A proposed combination of references is improper under 35 U.S.C. § 103 where the combination "would require a substantial reconstruction and redesign of the elements shown in [the base reference] as well as a change in the basic principles under which [the base reference] construction was designed to operate." *In re Ratti*, 270 F.2d 810, 813, 123 USPQ 349, 352 (CCPA 1959)

According to MPEP § 2145(III) at page 2100-160, although it may not be necessary for the specific structures of references applied in a rejection under 35 U.S.C. § 103 to be physically combinable with each other, the combination advanced by the Patent Office is still subject to the requirements that:

> the claimed combination cannot change the principle of operation of the primary reference or render the reference inoperable for its intended purpose. See MPEP § 2143.01. (Emphasis added).

C. **First Ground of Rejection**

Appellants submit that the rejection of Claims 1-7, 9, 11, 13, 14, 39, 41-50 and 56-61 under 35 U.S.C. § 103(a) over Chang in view of Murugesh and Arami, Goodyear, or Balance should be reversed for the following reasons.[2]

In the paragraph bridging pages 2-3 of the final Official Action, the Examiner contends that Chang discloses "the invention substantially as claimed," and further that Chang's device allegedly includes:

> a gas injector extending through the dielectric member such that a distal end of the gas injector body is exposed within the processing chamber and comprising a plurality of gas outlets 96/98 including at least one on-axis outlet 96 in the axial end surface and a spaced-apart off-axis outlet in the side surface. (Emphasis added).

Although the Examiner acknowledges that Chang "does not expressly disclose that the plurality of gas outlets includes at least one on-axis outlet in the axial end surface and a plurality of spaced-apart off-axis outlets in the side surface" (final Official Action at page 4, lines 1-3; emphasis added), the Examiner contends at page 4, first paragraph, of the final Official Action, that it would have been obvious to modify Chang's apparatus to comprise Murugesh's gas injector "in order to optimize the delivery of gas(es) into the chamber and in order to direct gas preferentially across a surface of the chamber" (emphasis added).

At page 11, lines 15-16, of the final Official Action, the Examiner contends that "in the primary reference of Chang some of the supplies provide gases to both outlets" (emphasis added). The Examiner acknowledges that Chang and Murugesh do not disclose a "common gas supply including a single third gas line in fluid

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[2] Claims 46 and 59 will not be discussed with respect to this ground of rejection.

communication with the first gas line and the second gas line" (final Official Action at page 4, lines 18-20; emphasis added).

Despite these acknowledged deficiencies of Chang and Murugesh with respect to the claimed subject matter, the Examiner contends that Arami, Goodyear or Ballance cures the deficiencies of Chang and Murugesh and that it would have been obvious to modify the Chang/Murugesh device to include a common gas supply "in order to enable the injection of the same gas, to the processing chamber, through the on-axis outlets and the off-axis outlets" (final Official Action at page 5, lines 11-13).

Appellants disagree with these assertions for the following reasons.

1. Claims 1-4, 6, 11, 13, 14, 41-43, 47, 48, 50, 56, 60 and 61 are Separately Patentable

a. The Applied References Do Not Suggest Replacing Chang's Gas Injector With Murugesh's Gas Distributor

FIG. 7 of Chang shows a top gas nozzle 96 extending through an opening in dome 50, and a top vent 98 supported on the upper surface of the dome.

The Examiner contends that Chang discloses a "body" comprising both the top gas nozzle 96 and the top vent 98, but has failed to make any factual findings with respect to such "side surface" in the alleged "body." However, the Patent Office is required to make specific factual findings with respect to the alleged motivation to combine references under an assertion of obviousness. *See In re Lee*, 61 USPQ2d 1430, 1433-34 (Fed. Cir. 2002), and MPEP § 2143.01, page 2100-130. Appellants submit that the gas nozzle 96 does not include "a side surface extending axially from the axial end surface" that includes even one off-axis outlet in such side surface,

much less "a plurality of spaced-apart off-axis outlets in the side surface" (emphasis added). To the extent that Chang discloses a concentric tube arrangement including a central tube with a flared opening surrounded above the dome by a wider housing, Chang's device includes, at most, two outlets, and those outlets are connected to different gas supplies, and neither of those openings is in a side surface of the "body."

The final Official Action states that Murugesh discloses an apparatus comprising a gas injector including a body with an axial end surface, a side surface extending axially from the axial end surface, at least one on-axis outlet 85 in the axial end surface and a plurality of circumferentially spaced-apart off-axis outlets 247 in the side surface (page 4, first paragraph). The final Official Action refers to FIGS. 2A, 2B and 3 of Murugesh.

The embodiment of the gas distributor 215 shown in FIGS. 2A and 2B of Murugesh includes an inlet 218 for receiving a cleaning gas, which is distributed to gas outlets 247 opening at the top surface. As such, the gas distributor 215 does not include either "at least one on-axis outlet in the axial end surface" or "a plurality of spaced-apart off-axis outlets in the side surface [where the side surface extends axially from the axial end surface of the body]," as recited in Claim 1.

The gas distributor structure shown in FIG. 3 of Murugesh includes a first gas distributor 65 and a second gas distributor 215 including first gas outlets 85 and second gas outlets 247, respectively. A process gas 70 is supplied to the first gas outlets 85 from a first gas delivery system 60 and flowed in a downward direction toward a substrate to process a substrate. A different gas, i.e., a cleaning gas, is supplied to the second gas outlets 247 of the second gas distributor 215 from a

second gas delivery system 200 (column 7, line 65, to column 8, line 26) and directed perpendicularly to the orientation of the first gas outlets 85 and toward the wall of chamber 30 to clean the chamber.

Clearly, replacing Chang's gas injector structure with Murugesh's gas distributor structure shown in FIG. 3 could not "optimize the delivery of gas(es) into the chamber ... in order to direct gas preferentially across a surface of the chamber" (emphasis added), as contended by the Examiner. Murugesh's apparatus is operable such that after the process gas 70 has been introduced into the chamber to process a surface of a substrate 25, the processed substrate is removed from the chamber and the process gas is exhausted from the chamber. Then, a cleaning gas having a different composition is supplied to a different gas outlet from a different gas supply and directed preferentially across a different surface in the process zone, such as the ceiling. Murugesh's apparatus shown in FIG. 3 is designed specifically to direct different gases, at different times, toward different surfaces in order to achieve the different purposes of processing the substrate with one gas and then cleaning the chamber with another gas.

Thus, the final Official Action has not provided the required motivation to replace Chang's gas injector with Murugesh's gas distributor.

b. The Applied Combination of References Teaches Away From the Claimed "Common Gas Supply"

As shown in FIG. 1 of Chang, the top gas nozzle 96 is in fluid communication with the gas source 100a (which supplies titanium source gas $TiCl_4$), while the top vent 98 is in fluid communication with the different gas source 100b (which supplies

H_2). Thus, the top gas nozzle 96 and top vent 98 are not in fluid communication with a common gas supply.

As discussed above, the Examiner contends that "in the primary reference of Chang some of the supplies provide gases to both outlets" (emphasis added). However, the Examiner has failed to make any factual findings to support this assertion. It is well established that the Patent Office is required to make specific factual findings with respect to the alleged motivation to combine references under an assertion of obviousness. As shown in FIG. 1 of Chang, gas source 100a supplies $TiCl_4$ to top gas nozzle 96 and gas source 100d supplies argon to the top gas nozzle 96, but neither gas source 100a nor gas source 100d also supplies gas to the top vent 98. The only gas source that supplies gas to the top vent 98 is the gas source 100b of H_2, but the gas source 100b does not also supply gas to the top gas nozzle 96. As such, Chang does not disclose a common gas supply that supplies the same gas to both the top gas nozzle 96 and the top vent 98. Thus, to the extent that the Examiner contends that Chang discloses a common gas supply in fluid communication with a first gas line and a second gas line, Chang does not support such contention.

Each of Chang and Murugesh discloses a gas injector structure that requires more than one gas supply, and more than one gas composition, to be operable to achieve its intended purpose. As such, Chang and Murugesh both teach away from a plasma processing system that includes a common gas supply to supply a common gas to an on-axis outlet and off-axis outlets of a gas injector at the same time. Chang's apparatus includes different gas supplies to supply a source of titanium to form a film and a source of a plasma forming gas. Murugesh's apparatus

requires different gas supplies in order to be able to process a substrate with one gas composition and to clean the chamber with another gas composition. The Examiner has improperly ignored those portions of both Chang and Murugesh that would have led one skilled in the art away from the subject matter recited in Claim 1.

Appellants submit that each of Arami, Goodyear and Ballance fails to provide the required suggestion or motivation to further modify Chang's apparatus to include a common gas supply, as recited in Claim 1. The Examiner contends that such further modification of Chang would have been obvious "in order to enable the injection of the same gas, to the processing chamber, through the on-axis outlets and the off-axis outlets" (emphasis added). However, this assertion improperly ignores the critical fact that each of Chang and Murugesh requires more than one gas supply to be able to achieve its intended purpose. As such, the applied combination of references teaches away from the combination of features recited in Claim 1.

c. The Modification Advanced in the Official Action Would Destroy the Device of the Base Reference (Chang) for its Intended Purpose

First, Chang's gas nozzle 96 and top vent 98 having a co-axial flared tube arrangement inject different gases 96a and 98a, respectively, downwardly through the at most two outlets toward a semiconductor substrate. In stark contrast to Chang's gas injector structure, Murugesh's gas distributor structure is designed to process a substrate and clean the chamber wall, which is far removed from the substrate. As such, Murugesh's arrangement does not inject both the gas from the first gas outlets 85 and the (different) gas from the second gas outlets 247 downwardly toward a semiconductor substrate, as in Chang's structure. Thus, for

this reason, replacing Chang's gas injector structure with Murugesh's gas distributor structure would destroy the device of the base reference, Chang, for its intended purpose. Therefore, for this reason, the applied combination of reference would not have rendered obvious the claimed subject matter. *See Ex Parte Westphalen*, 159 USPQ at 508 and *Ex Parte Hartmann*, 186 USPQ at 367.

Second, the Examiner contends that it would have been obvious to further modify Chang's device to include a common gas supply "in order to enable the injection of the same gas, to the processing chamber, through the on-axis outlets and the off-axis outlets" (emphasis added). However, each of Chang and Murugesh requires more than one gas supply in order to be able to supply different gases to the different outlets. Thus, modifying the Chang/Murugesh apparatus in view of Arami, Goodyear or Ballance in the manner advanced in the final Official Action to include a common gas supply in fluid communication with the first gas outlets 85 and the second gas outlets 247 would make the Chang/Murugesh structure inoperable, i.e., destroy the structure, for its intended purpose. Therefore, for this additional reason, the applied combination of references would not have rendered obvious the subject matter recited in Claim 1.

Therefore, the subject matter recited in Claims 1-4, 6, 11, 13, 14, 41-43, 47, 48, 50, 56, 60 and 61 is patentable over the applied combination of references.

2. Claim 5 is Separately Patentable

Dependent Claim 5 recites an additional combination of features that further patentably distinguishes the claimed subject matter over the applied combination of references. Namely, Claim 5 recites that "the injector body is cylindrical shaped and

the off-axis outlets are circumferentially spaced apart." In contrast, Murugesh's gas distributor shown in FIG. 3 clearly does not have a cylindrical shaped body, as claimed. Accordingly, the applied combination of references does not include each and every feature recited in Claim 5, and thus does not support any alleged case of *prima facie* obviousness.

Therefore, the subject matter recited in Claim 5 is also patentable over the applied combination of references.

3. Claim 39 is Separately Patentable

Dependent Claim 39 recites an additional combination of features that further patentably distinguishes the claimed subject matter over the applied combination of references. Namely, Claim 39 recites the features of "the on-axis outlet and the off-axis outlets are oriented at different angles relative to an exposed surface of the substrate" (emphasis added). As explained above, Murugesh's first gas outlets 85 and second gas outlets 247 are not oriented toward a surface, i.e., the same surface, much less toward an exposed surface of a substrate. Accordingly, the applied combination of references does not include each and every feature recited in Claim 39, and thus does not support any alleged case of *prima facie* obviousness.

Therefore, the subject matter recited Claim 39 is also patentable over the applied combination of references.

4. Claims 7, 44 and 57 are Separately Patentable

Independent Claim 7 recites a plasma processing system, which comprises, *inter alia*, a plasma processing chamber; ... a dielectric member having an interior surface facing the substrate support, wherein the dielectric member forms a wall of

the processing chamber; a gas injector extending through the dielectric member such that a distal end of the gas injector is exposed within the processing chamber, the gas injector including a planar axial end face having an on-axis outlet therein and a conical side surface having off-axis outlets therein, the on-axis outlet receiving process gas from a central passage in the injector and the off-axis outlets receiving process gas from an annular passage surrounding the central passage, ... a common gas supply in fluid communication with a first gas line and a second gas line, the first gas line being in fluid communication with the on-axis outlet but not with the off-axis outlets and the second gas line being in fluid communication with the off-axis outlets but not with the on-axis outlet ...." (Emphasis added).

As discussed above, the applied combination of references does not suggest modifying Chang in the manner advanced in the Official Action to include a common gas supply.

In addition, Murugesh's gas distributor does not have "a conical side surface having off-axis outlets therein," as claimed.

Arami, Goodyear and Ballance each disclose a showerhead-type gas injection arrangement. For example, see FIG. 2 of Arami, FIG. 1 of Goodyear and FIG. 1 of Ballance. As such, each of these references fails to suggest a gas injector including a planar axial end face having an on-axis outlet therein and a conical side surface having off-axis outlets therein.

Accordingly, the applied combination of references does not include each and every feature recited in Claim 7, and thus does not support any alleged case of *prima facie* obviousness.

Therefore, the subject matter recited in Claims 7, 44 and 57 is also patentable over the applied combination of references.

5. Claims 9, 45, 49 and 58 are Separately Patentable

Independent Claim 9, as amended, recites a plasma processing system, which comprises, *inter alia*, "a plasma processing chamber; ... a dielectric member having an interior surface facing the substrate support, wherein the dielectric member forms a wall of the processing chamber; a gas injector extending through the dielectric member such that a distal end of the gas injector is exposed within the processing chamber, the gas injector including at least one on-axis outlet which injects process gas in an axial direction perpendicular to a plane parallel to an exposed surface of the substrate and off-axis gas outlets which inject process gas at an acute angle relative to the plane parallel to the exposed surface of the substrate, the off-axis outlets being circumferentially spaced apart from each other, ... a common gas supply in fluid communication with a first gas line and a second gas line, the first gas line being in fluid communication with the on-axis outlet but not with the off-axis outlets and the second gas line being in fluid communication with the off-axis outlets but not with the on-axis outlet ...." (Emphasis added).

For reasons discussed above, the applied combination of references fails to suggest modifying Chang's gas injector to include a "a common gas supply in fluid communication with a first gas line and a second gas line, the first gas line being in fluid communication with the on-axis outlet but not with the off-axis outlets and the second gas line being in fluid communication with the off-axis outlets but not with the on-axis outlet" (emphasis added).

Furthermore, Murugesh's gas distributor does not include the features of "at least one on-axis outlet which injects process gas in an axial direction perpendicular to a plane parallel to an exposed surface of the substrate and off-axis gas outlets which inject process gas at an acute angle relative to the plane parallel to the exposed surface of the substrate" (emphasis added). In contrast, Murugesh's gas distributor does not include such off-axis outlets that inject process gas at an acute angle relative to a plane parallel to an exposed surface of a substrate. Rather, the gas outlets 247 direct the cleaning gas toward the chamber wall in a direction parallel to a plane parallel to an exposed surface of a substrate (*see*, *e.g.*, substrate 25 shown in FIG. 1A). As such, replacing Chang's gas injector with Murugesh's gas distributor structure would not result in a gas injector that includes the combination of features recited in Claim 9, including the features of "off-axis gas outlets which inject process gas at an acute angle relative to the plane parallel to the exposed surface of the substrate."

Accordingly, the applied combination of references does not include each and every feature recited in Claim 9, and thus does not support any alleged case of *prima facie* obviousness. Therefore, the subject matter recited in Claims 9, 45, 49 and 58 is also patentable over the applied combination of references.

D. Second Ground of Rejection

Appellants submit that the rejection of Claims 8, 10 and 40 under 35 U.S.C. § 103(a) over Chang in view of Murugesh and Arami, Goodyear, or Balance, and further in view of Ni should be reversed for the following reasons.[3]

Claim 8 depends from Claim 1. Although the Examiner acknowledges that Chang, Murugesh, Arami, Goodyear and Ballance fail to suggest the features of "the gas injector is removably mounted in the dielectric window and supplies process gas into a central region of the chamber," as recited in Claim 1, the Examiner contends that Ni discloses these features and that it would have been obvious to modify Chang's apparatus to include them. Appellants disagree.

As shown in FIGS. 2a-2c of the present application, the gas injector 22 is removably mounted in the dielectric window 20. In other words, the gas injector 22 can be removed from the opening in the dielectric window 20 by pulling the gas injector in the upward direction.

In stark contrast to the claimed removable gas injector, Murugesh's gas distributor shown in FIG. 3 has a T-shaped construction and, as such, cannot be removed from a dielectric window by pulling the gas distributor in an upward direction.

Furthermore, Ni also fails to cure the above-described deficiencies of Chang. At the least, Ni does not suggest modifying the shape of Murugesh's gas distributor to result in the claimed gas injector, which is "removably mounted in the dielectric window," as recited in Claim 8. Thus, Claim 8 also is patentable.

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[3] Claims 46 and 59 will be discussed with respect to this ground of rejection.

Independent Claim 10 recites a plasma processing system, which comprises, *inter alia*, "a plasma processing chamber; ... a dielectric member having an interior surface facing the substrate support, wherein the dielectric member forms a wall of the processing chamber; a gas injector removably mounted in an opening in the dielectric member and extending through the dielectric member such that a single distal end of the gas injector is exposed within the processing chamber, a vacuum seal being provided between the gas injector and the dielectric window, the gas injector including a plurality of gas outlets in the single distal end which are each located below the interior surface of the dielectric member, a common gas supply ...." (Emphasis added). For reasons stated above, the subject matter recited in Claims 10, 40, 46 and 59 is also patentable.

E. Third Ground of Rejection

Appellants submit that the rejection of Claim 15 under 35 U.S.C. § 103(a) over Chang in view of Murugesh and Arami, Goodyear, or Balance, and further in view of Powell should be reversed for the following reasons.

Claim 15 depends from Claim 1. In the paragraph bridging pages 8 to 9 of the final Official Action, the Examiner contends that Powell discloses an electrically conducting shield and that it would have been obvious to modify Chang's apparatus to include such shield. However, at the least, Powell also does not suggest modifying Chang's device to include a "common gas supply." Thus, Claim 15 is also patentable.

F. Fourth Ground of Rejection

Appellants submit that the rejection of Claims 51-55 under 35 U.S.C. § 103(a) over Chang in view of Murugesh and Arami, Goodyear, or Balance, and further in view of Hassan should be reversed for the following reasons.

Claims 51, 52, 53, 54 and 55 depend from Claims 1, 7, 9, 41 and 42, respectively. At page 9, last paragraph of the final Official Action, the Examiner acknowledges that Chang, Murugesh, Arami, Goodyear and Ballance fail to suggest on-axis and off-axis outlets that include an interior orifice contoured to provide sonic or supersonic flow therethrough. However, the final official Action contends that Hassan cures this deficiency.

Appellants submit that Hassan fails to cure the above-described deficiencies of Chang and the other applied references with respect to the subject matter recited in independent Claims 1, 7, 9, 41 and 42, which is included in Claims 51-55, respectively. Thus, Claims 51-55 are also patentable.

VIII. Claims Appendix

See the attached Claims Appendix for a copy of the claims involved in the appeal.

I Conclusion

For the foregoing reasons, reversal of the rejection of Claims 1-11, 13-15 and 39-61 is respectfully requested.

Respectfully submitted,
Burns, Doane, Swecker & Mathis, L.L.P

Date May 17, 2005 By: _____
Edward A. Brown
Registration No. 35,033

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VIII. CLAIMS APPENDIX

The Appealed Claims

1. (Previously Presented) A plasma processing system comprising:

a plasma processing chamber;

a vacuum pump connected to the processing chamber;

a substrate support on which a substrate is processed within the processing chamber;

a dielectric member having an interior surface facing the substrate support, wherein the dielectric member forms a wall of the processing chamber;

a gas injector extending through the dielectric member, the gas injector comprising a body including an axial end surface exposed within the processing chamber, a side surface extending axially from the axial end surface, and a plurality of gas outlets including at least one on-axis outlet in the axial end surface and a plurality of spaced-apart off-axis outlets in the side surface;

a common gas supply in fluid communication with a first gas line and a second gas line, the first gas line being in fluid communication with the on-axis outlet but not with the off-axis outlets and the second gas line being in fluid communication with the off-axis outlets but not with the on-axis outlet;

flow controllers operable to supply process gas from the common gas supply at flow rates that are independently varied between the on-axis outlet and the off-axis outlets into the processing chamber; and

an RF energy source which inductively couples RF energy through the dielectric member and into the chamber to energize the process gas into a plasma state to process the substrate.

2. (Original) The system of Claim 1, wherein the system is a high density plasma chemical vapor deposition system or a high density plasma etching system.

3. (Original) The system of Claim 1, wherein the RF energy source comprises an RF antenna and the gas injector injects the process gas toward a primary plasma generation zone in the chamber.

4. (Previously Presented) The system of Claim 1, wherein the first gas line is in fluid communication with an axially extending central bore in the injector body, and the second gas line is in fluid communication with an annular gas passage surrounding the central bore.

5. (Previously Presented) The system of Claim 1, wherein the injector body is cylindrical shaped and the off-axis outlets are circumferentially spaced apart.

6. (Original) The system of Claim 1, wherein the gas injector injects the process gas at a subsonic, sonic, or supersonic velocity.

7. (Previously Presented) A plasma processing system comprising:

a plasma processing chamber;

a vacuum pump connected to the processing chamber;

a substrate support on which a substrate is processed within the processing chamber;

a dielectric member having an interior surface facing the substrate support, wherein the dielectric member forms a wall of the processing chamber;

a gas injector extending through the dielectric member such that a distal end of the gas injector is exposed within the processing chamber, the gas injector including a planar axial end face having an on-axis outlet therein and a conical side surface having off-axis outlets therein, the on-axis outlet receiving process gas from a central passage in the injector and the off-axis outlets receiving process gas from an annular passage surrounding the central passage, the gas injector supplying process gas at flow rates that are independently varied between at least some of the outlets including the on-axis outlet into the processing chamber;

a common gas supply in fluid communication with a first gas line and a second gas line, the first gas line being in fluid communication with the on-axis outlet but not with the off-axis outlets and the second gas line being in fluid communication with the off-axis outlets but not with the on-axis outlet; and

an RF energy source which inductively couples RF energy through the dielectric member and into the chamber to energize the process gas into a plasma state to process the substrate.

8. (Original) The system of Claim 1, wherein the gas injector is removably mounted in the dielectric window and supplies the process gas into a central region of the chamber.

9. (Previously Presented) A plasma processing system comprising:

a plasma processing chamber;

a vacuum pump connected to the processing chamber;

a substrate support on which a substrate is processed within the processing chamber;

a dielectric member having an interior surface facing the substrate support, wherein the dielectric member forms a wall of the processing chamber;

a gas injector extending through the dielectric member such that a distal end of the gas injector is exposed within the processing chamber, the gas injector including at least one on-axis outlet which injects process gas in an axial direction perpendicular to a plane parallel to an exposed surface of the substrate and off-axis gas outlets which inject process gas at an acute angle relative to the plane parallel to the exposed surface of the substrate, the off-axis outlets being circumferentially spaced apart from each other, the gas injector supplying process gas at flow rates that are independently varied between at least some of the outlets into the processing chamber;

a common gas supply in fluid communication with a first gas line and a second gas line, the first gas line being in fluid communication with the on-axis outlet but not with the off-axis outlets and the second gas line being in fluid communication with the off-axis outlets but not with the on-axis outlet; and

an RF energy source which inductively couples RF energy through the dielectric member and into the chamber to energize the process gas into a plasma state to process the substrate.

10. (Previously Presented) A plasma processing system comprising:

a plasma processing chamber;

a vacuum pump connected to the processing chamber;

a substrate support on which a substrate is processed within the processing chamber;

a dielectric member having an interior surface facing the substrate support, wherein the dielectric member forms a wall of the processing chamber;

a gas injector removably mounted in an opening in the dielectric member and extending through the dielectric member such that a single distal end of the gas injector is exposed within the processing chamber, a vacuum seal being provided between the gas injector and the dielectric window, the gas injector including a plurality of gas outlets in the single distal end which are each located below the interior surface of the dielectric member, the gas outlets supplying process gas at flow rates that are independently varied between at least some of the outlets into the processing chamber;

a common gas supply in fluid communication with a first gas line and a second gas line, the first gas line being in fluid communication with the on-axis outlet but not with the off-axis outlets and the second gas line being in fluid communication with the off-axis outlets but not with the on-axis outlet; and

an RF energy source which inductively couples RF energy through the dielectric member and into the chamber to energize the process gas into a plasma state to process the substrate.

11. (Original) The system of Claim 1, wherein the RF energy source comprises an RF antenna in the form of a planar or non-planar spiral coil and the gas injector injects the process gas toward a primary plasma generation zone in the chamber.

13. (Original) The system of Claim 1, wherein the ratio of gas flow through at least some of the gas outlets is independently varied using variable flow restriction devices.

14. (Original) The system of Claim 1, wherein the ratio of gas flow through at least some of the gas outlets is independently varied using a network of valves and throttling elements.

15. (Original) The system of Claim 1, wherein the gas injector is further provided with an electrically conducting shield which minimizes plasma ignition within gas passages located in the gas injector.

39. (Previously Presented) The system of Claim 1, wherein the on-axis outlet and the off-axis outlets are oriented at different angles relative to an exposed surface of the substrate.

40. (Previously Presented) The system of Claim 10, wherein the plurality of gas outlets in the single distal end of the gas injector are oriented at different angles relative to an exposed surface of the substrate.

41. (Previously Presented) A plasma processing system, comprising:

a plasma processing chamber;

a vacuum pump connected to the processing chamber;

a substrate support on which a substrate is supported within the processing chamber;

a dielectric member having an interior surface facing the substrate support, the dielectric member forming a wall of the processing chamber;

a gas injector body extending through the dielectric member such that a distal end of the gas injector body is exposed within the processing chamber, the gas injector body including a plurality of gas outlets which are disposed within the processing chamber below the interior surface of the dielectric member;

a common gas supply in fluid communication with a first gas line and a second gas line, the first gas line being in fluid communication with at least one first outlet but not with second outlets and the second gas line being in fluid communication with the second outlets but not with the first outlet;

flow controllers providing independently adjustable flow rates of process gas between at least some of the outlets into the processing chamber; and

an RF energy source which inductively couples RF energy through the dielectric member and into the chamber to energize the process gas into a plasma state to process the substrate.

42. (Previously Presented) A plasma processing system comprising:

a plasma processing chamber;

a vacuum pump connected to the processing chamber;

a substrate support on which a substrate is processed within the processing chamber;

a dielectric member having an interior surface facing the substrate support, the dielectric member forming a wall of the processing chamber;

a gas injector comprising an injector body including at least first and second gas inlets, at least first and second gas passages, an axial end surface, a side surface extending from the axial end surface toward the interior surface of the dielectric member, and at least a first gas outlet in the axial end surface and a plurality of second gas outlets in the side surface at locations between the axial end surface and the interior surface of the dielectric member, the first gas passage being in fluid communication with the first inlet and first outlet, and the second gas passage being in fluid communication with the second inlet and second outlet, the first and second gas passages not being in fluid communication with each other;

a common gas supply in fluid communication with the first gas passage and the second gas passage;

flow controllers providing independently adjustable flow rates of gas through the first and second outlets; and

an RF energy source which inductively couples RF energy through the dielectric member and into the chamber to energize the process gas into a plasma state to process the substrate.

43. (Previously Presented) The system of Claim 1, wherein the system is a plasma etching system.

44. (Previously Presented) The system of Claim 7, wherein the system is a plasma etching system.

45. (Previously Presented) The system of Claim 9, wherein the system is a plasma etching system.

46. (Previously Presented) The system of Claim 10, wherein the system is a plasma etching system.

47. (Previously Presented) The system of Claim 41, wherein the system is a plasma etching system.

48. (Previously Presented) The system of Claim 42, wherein the system is a plasma etching system.

49. (Previously Presented) The system of Claim 9, wherein the off-axis outlets are circumferentially spaced apart from each other by 120°, 90° or 45°.

50. (Previously Presented) The system of Claim 1, wherein the common gas supply comprises a single third gas line in fluid communication with the first gas line and the second gas line.

51. (Previously Presented) The system of Claim 1, wherein each of the on-axis and the off-axis outlets includes an interior orifice contoured to provide sonic or supersonic flow therethrough.

52. (Previously Presented) The system of Claim 7, wherein each of the on-axis and the off-axis outlets includes an interior orifice contoured to provide sonic or supersonic flow therethrough.

53. (Previously Presented) The system of Claim 9, wherein each of the gas outlets includes an interior orifice contoured to provide sonic or supersonic flow therethrough.

54. (Previously Presented) The system of Claim 41, wherein each of the gas outlets includes an interior orifice contoured to provide sonic or supersonic flow therethrough.

55. (Previously Presented) The system of Claim 42, wherein each of the first and second gas outlets includes an interior orifice contoured to provide sonic or supersonic flow therethrough.

56. (Previously Presented) The system of Claim 1, wherein at least one of the on-axis and the off-axis outlets has a uniform diameter along the entire length thereof.

57. (Previously Presented) The system of Claim 7, wherein at least one of the on-axis and the off-axis outlets has a uniform diameter along the entire length thereof.

58. (Previously Presented) The system of Claim 9, wherein at least one of the gas outlets has a uniform diameter along the entire length thereof.

59. (Previously Presented) The system of Claim 10, wherein at least one of the gas outlets has a uniform diameter along the entire length thereof.

60. (Previously Presented) The system of Claim 41, wherein at least one of the gas outlets has a uniform diameter along the entire length thereof.

61. (Previously Presented) The system of Claim 42, wherein at least one of the first and second gas outlets has a uniform diameter along the entire length thereof.